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Blends of Chemically Treated Cotton Fibers
With Untreated Cotton Fibers
To Improve Abrasion Resistance
Of Durable Press Garments

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BLEND S OF CHEMICALLY TREATED COTTON FIBERS WITH UNTREATED COTTON FIBERS TO IMPROVE ABRASION RESISTANCE OF DURABLE PRESS GARMENTS

by

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INTRODUCTION

The evolution of a resin system for the treatment of cotton fabrics that permitted a time delay between resin application and curing seemed to offer a solution to many problems facing the converter or garment manufacturer as a result of the introduction of wash-wear, minimum-care treatments for cotton. All-cotton fabrics treated with deferred-cure resins overcame one type of problem; but, unfortunately, they created more problems than were solved. Among the properties most adversely affected by the deferred-cure technique were the ability of the fabrics to resist abrasion, and the losses incurred in tear and tensile strength.

While the application of resins to obtain wash-wear or easy-care properties in apparel textile items has long been known to significantly lower their abrasion resistance and strength, the problem was not too serious when chemical add-ons of only 3 to 4 percent were used. In the case of the deferred-cure resins, considerably higher chemical add-ons and higher curing temperatures have been used (5)^{2/} than in the case of the conventional resins to speed production and to accomplish the curing of multiple layers of fabrics.

The overall result of these changes has been that some permanent-press cotton apparel items were degraded to the point where significant abrasion damage resulted in fewer than 10 wash and tumble-drying cycles.

In an effort to increase the wear life of permanent-press garments, the textile industry has resorted to the practice of

blending selected synthetic fibers with cotton.

Reid, Reinhardt, and Markezich (7) suggested that edge abrasion is presently of the greatest concern to the cotton textile industry. Such abrasion includes the fraying of cuffs and of the creases in trousers. Other authors showed that the abrasion observed in trousers is a combination of both wet and dry abrasion, each of which proceed according to different mechanisms (3, 4) with the greatest damage occurring at the lower moisture content (7). Because each of the above-referenced studies were made on cotton fabrics that had been treated with conventional wash-wear resins, they cannot be extrapolated to durable press-type treatments. However, in durable press-treated garments the wear due to the washing and tumble-drying cycle might logically be expected to be concentrated at specific creased points due to the increased sharpness obtained in creases with these durable press resins.

Some evidence exists that with the inclusion of nylon in blends with cotton, for example, the ratio of tearing strength to the cloth strength per thread increases with the proportion of nylon probably due to the variation in the single thread slippage forces. In such blends the tear ratio is usually greater for fabrics with cover factors of 9 than for fabrics with cover factors of 14. Consequently, the increase in tear ratio as the nylon is increased is associated with the frictional properties or the smoothness of the yarns (2, pp. 24-26). There is also evidence that the thermoplastic characteristics of nylon or polyester fibers contribute materially to crease retention. Blends of

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^{2/} Underscored figures in parentheses refer to Literature Cited at end of publication.

cotton and nylon containing 20 percent nylon have approximately double the resistance to abrasion damage as 100 percent cotton when measured by the Shirley Institute technique, which uses a 5/8 inch diameter disc of fabric mounted around a 1/2 inch diameter steel ball which in turn rests against a reciprocating gray cotton canvas belt (2, p. 32).

Benefits obtained by blending synthetic fibers with cotton fibers make it apparent that an area of research on cotton has not been exploited adequately and that the blending of cotton fibers, which have been impregnated with deferred-cure type resins with untreated cotton fibers, might offer a means of enhancing the ability of cotton fabrics to withstand abrasion damage.

Based on the above premise, research was undertaken that can be considered as a radical departure from conventional resin impregnation of cotton textiles. The work was designed to (1) ascertain the feasibility of mechanically processing blends of cotton fibers--a portion of which had been impregnated with (a) deferred-cure resins and (b) thermoplastic resins; (2) compare the performance of such blends with conventional cotton fabrics impregnated with deferred-

cure resins in the conventional pad dry manner; and (3) study the physical properties of blends of impregnated and untreated cotton fibers in yarn, fabric, and simulated trouser cuffs. This paper reports research results obtained on samples of yarns, fabrics, and simulated trouser cuffs made from blends of resin impregnated untreated cotton fibers.

EXPERIMENTAL PLAN

For the initial phases of this research in which the feasibility of mechanically processing cotton fibers that had been impregnated with resin was to be evaluated, six levels of resin add-ons were selected. These were 7.0, 9.0, 12.0, and 18.0 percent of the deferred-cure resin, and 1.5 and 3.0 percent of the thermoplastic resin. These treated fibers were then blended with scoured and bleached raw cotton in the proportions of 75 percent treated fibers-25 percent untreated fibers, 50 percent each of treated and untreated fibers, and 25 percent treated fibers-75 percent untreated fibers. The fibers were blended either at the picker or at the drawing frame as seemed appropriate. Also, blends containing 33-1/3 percent each of deferred-cure resin impregnated fibers, thermoplastic resin impregnated fibers, and scoured and bleached fibers (table 1) were made

Table 1. --Experimental plan

Resin Content treated fibers	Treated fiber content in blends for filling only		
	Percent	Percent	Percent
Methylol imidazolidone:			
7 percent - - - - -	75	50	25
9 percent - - - - -	75	50	25
12 percent - - - - -	75	50	25
18 percent - - - - -	75	50	25
Acrylic:			
3 percent - - - - -	--	33.3	--
1-1/2 percent - - - - -	--	33.3	--
	Treated fiber content in blends both warp and filling		
Methylol imidazolidone:			
11 percent warp - - - - -	--	50	--
11 to 12 percent filling - - - - -	75	50	25

To obtain preliminary data on how yarns made from these blends might be expected to perform in a fabric they were used as the filling yarns in a filling face sateen.

A collation of the preliminary data seemed so promising that it was deemed desirable to evaluate the fabrics under conditions where both warp and filling were treated, and at the same time in a fabric that was more representative of those used in conventional men's slacks. For this purpose a 3/2 twill was selected. For these experimental fabrics, the warp yarns were made from 50 percent blends of deferred-cure resin impregnated and untreated fibers only. For the warp, containing 50 percent deferred-cure resin impregnated fibers and 50 percent scoured and bleached fibers, rawstock was treated to a 10.4 percent dry resin add-ons. This material was then blended at the picker with a corresponding weight on untreated scoured and bleached fibers. Plyed yarns were used to avoid the necessity of sizing the experimental warps. Fiber blends for the filling yarns for the 3/2 steep twill fabrics were made to the same 75 to 25, 50, 25 to 75 and 33-1/3 percent levels as were used previously with the sateen fabrics. For the purposes of this report data are presented only on the twill fabrics.

EXPERIMENTAL MATERIALS

The requirement that the cotton to be processed should be in the most receptive condition to accept the resin treatment resulted in the procurement of appropriate quantities of scoured and bleached medium 1-1/16 inch staple cotton. The rawstock was scoured at 235° F. for 30 minutes using PermaKleer 80^{3/} and soda ash. Bleaching was carried out at 190° F. for 1 hour using sodium silicate, soda ash, and hydrogen peroxide. Two 10-minute washings were then used, the first at 190° F., and the second at 130° F. The scoured and bleached rawstock was then given an aftertreatment consisting of ammonium chloride and Seycolube K LW for 20 min. at 120° F.

For the deferred cure resin Permafresh 183 (methylol imidazolidone) was selected as representative.

For the thermoplastic resin, because several degrees of resin hardness were desired, four were selected HA 8, HA 12, HA 20, and polycryl 7 F 12. Each of these are of the self crosslinking acrylic type.

CHEMICAL TREATMENT

The scoured and bleached cotton was opened and processed into 13 oz. per yard picker laps. The picker laps were then divided into 14 in. wide strips and encased in cotton gauze to provide sufficient support so that the material could be chemically treated in a small experimental padder.

A treating solution containing a calculated 10 percent methylol imidazolidone solids was used. The cotton was subjected to two dips and two nips, with the wet pickup of the existing cotton controlled to 95 percent. The feed rate was 0.75 yards per minute with a residence time in the padder of 2-1/3 minutes. From the second nip the treated material passed into a continuous festoon-type dryer. Maximum air temperature in the dryer was 200° F. with a residence time of 25 minutes, and an exit moisture content of 10 to 12 percent. The treated cotton was equilibrated for 24 hours, then sampled. The resin add-on, based on nitrogen content, was 7.9 percent. Similar procedures were used with treating bath solids calculated concentrations of 20, 14, and 9 percent. By varying the wet pickup slightly, product rawstock containing 18.1, 12.1, and 8.8 percent resin add-ons, based on the Kjeldahl tests, were obtained.

Similar procedures were used to treat 10-pound batches of fibers with self-cross-linking acrylic resins. By use of the analytical technique of Kantner and Hoey (6), the resin content of the first of these was 2.8 percent, and the second, 1.5 percent.

MECHANICAL PROCESSING

The experimental plan for this research involved the preparation of blends containing 25, 50, and 75 percent treated fibers. To achieve such blends several techniques were used. To prepare the 50 percent impregnated fiber blend, strips of the impregnated picker lap were placed on top of an equal weight of untreated picker lap (made from

^{3/} Trade names are used in this publication solely to provide specific information. Mention of a trade name does not constitute a guarantee or warranty of the product by the U.S. Department of Agriculture, or an endorsement by the Department over other products not mentioned.

the same scoured and bleached cotton raw-stock as the treated material) on the apron of the picker and a 16 oz./yd. lap was produced. The lap containing the blend was then carded on a metallic clothed card at a sliver production rate of 10 lb./hr. The sliver was drawn twice and made into roving and then spun into 30/1 (20 Tex.) yarn using a 3.5 twist multiplier.

A 25 percent treated fiber content blend was made by feeding three ends of the card sliver containing 50 percent impregnated fibers and 50 percent untreated fibers and three ends of untreated sliver to the drawing frame and drawing twice. This material was also spun into a 30/1 filling yarn using a 3.5 TM. A 75 percent treated fiber, 25 percent untreated fiber blend was made by sandwiching untreated rawstock picker lap between the treated picker lap. A 16 oz./yd. lap was produced. This lap was carded as above, and drawn twice, formed into roving, and then spun into 30/1 filling yarn having a 3.5 TM.

These procedures were repeated for each level of chemical add-on. Sufficient yarn was made in each case to provide samples for physical testing and to weave fabric to make simulated trouser cuffs for wash-tumble drying tests.

To evaluate the possible improvement in the performance characteristics of such blends when thermoplastic resins were present, as well as the thermosetting resins, a series of blends were made at the drawing frame from sliver containing 100 percent fibers treated with a reactive acrylic resin and from sliver containing 50 percent of the thermosetting resin impregnated fibers and 50 percent untreated fibers. The blend was achieved by feeding four ends of the 50 percent sliver containing the thermosetting resin-treated fibers, and two ends of the sliver containing 100 percent of acrylic-treated fibers. The resulting drawing sliver contained 33-1/3 percent each of acrylic treated fibers, methylol imidazolidone impregnated fibers, and scoured and bleached fibers. The drawing sliver was then converted into roving and spun into 30/1 filling yarn with a 3.5 TM.

PREPARATION OF SAMPLES FOR EVALUATION

Sample trouser legs 11-5/8 inches long by 9-5/8 inches wide with a standard 1-5/8 inch cuff were made in quadruplicate from each experimental fabric. Two of the trouser leg-cuff samples were cut with the length of the pants leg parallel to the warp direction of the fabric, and two with the length of the pants leg parallel to the filling direction of the fabric.

Standard sewing techniques were used in making up these samples. In the case of the first lot of the sateen weave fabrics, creases were hand-ironed into the fabrics with an electric iron set at wash-wear temperature.

For the balance of the sateen fabrics all of the twill fabrics, creases were set by a commercial laundry steam press. The conditions in this case were 90 pounds steam pressure, steam on for 4 seconds, followed by an 11-second holding time. Temperature of pressing was 320° F.

Immediately following pressing, all samples were placed in a cabinet-type, gas-fired curing oven and cured at 320° F. for 8 minutes, except where curing time was the variable being evaluated.

The cured samples were then equilibrated for at least 24 hours before any testing was done.

Physical testing data on the initial batch of sateen samples were erratic. Therefore, all fabrics to be tested were washed one time before flex and flat abrasion tests were run.

EVALUATION FOR ABRASION RESISTANCE

Abrasion evaluations both flat and flex were carried out on the respective fabrics.

Approximately 5 yards of fabric were made from each experimental blend. From these samples of fabric two simulated trouser legs and cuffs were made from fabric cut in the warp direction and two from fabric cut in the filling direction.

Samples were then separated into approximately 9-pound batches for the first series of sateen materials, and into 4-pound batches for subsequent samples of both sateen and twill.

The AATCC Method 88A-1964T was used in the wash-tumble drying tests (1, pt. II, pp. b 99-b 103) with high-water level and water temperature about 101° F. Washing cycle time was 32-1/2 min. and the drying time 60 min. For purposes of comparison, samples of the fabrics containing the blends were duplicated using untreated cotton. These controls were then treated to various add-on levels by padding--two dips and two nips. Cuffs from these fabrics were included in wash-dry tests in all but the first series of experiments.

The sample simulated cuffs were visually examined after each washing-drying cycle, and evaluated for wear spots, broken yarns, and holes. In addition, samples were visually graded for flat drying appearance.

A comparison series wherein pairs of samples were washed in the same washer but half were dried in an electric dryer and half in a gas dryer was made to ascertain if noticeable differences in abrasion could be observed.

RESULTS AND DISCUSSION

Data will not be presented on the preliminary experimental sateen fabrics, be-

cause they were not truly representative of fabrics presently treated with the deferred-cure resins, and also because blends of treated fibers were used only in filling yarns.

Data are presented on the 3/2 steep twill fabrics, the yarns going into them, and the performance of the simulated trouser cuffs made from them as measured by laboratory abrasion tests and washing and tumble drying in home-type laundry equipment. Some comparisons are made of the performance of both twill and sateen in simulated trouser cuffs.

The physical properties of the 50/2 (24 Tex) warp yarns and the 13.5/1 (44 Tex) filling yarns made from blends of treated and untreated fibers along with similar data for control yarns made from scoured and bleached rawstock are given in table 2. When the percentage of resinated fibers was increased, the yarn became weaker. End breakage during spinning of the 50/1 (12 Tex) warp yarns made from the 50/50 blend of untreated and impregnated fibers was 44.7, or more than twice as high as the 19.7 ends down per 1,000 spindle hours for the control 50/1 yarns. However, 1-1/16 inch cotton is rather short for spinning 50/1 yarn. No end breakage occurred while spinning the 13.5/1 control filling and the short yardages of 13.5/1 filling yarns from the impregnated and untreated fibers.

Table 2. --Physical properties of experimental and control yarns nominal 50/2 warp and 13.5/1 filling

Item		Single strand				Ends down/ 1000 spindle hours
		Yarn number	Break factor	Strength C. V.	Elongation- at-break	
		CSP	Pct.	Pct.		
Percent						
Treated	Untreated					
Filling:						
25	75	13. 31/1	297	16. 14	7. 60	0
50	50	13. 46/1	272	14. 05	7. 15	0
75	25	13. 26/1	264	12. 22	7. 35	0
	100	13. 19/1	322	8. 77	7. 85	0
Warp:						
50	50	51. 02/2	253	12. 55	6. 40	44. 7
	100	50. 34/2	287	11. 34	6. 50	19. 7

Some minor mechanical processing problems were introduced where the thermoplastic resin-treated fibers were used in the blends, and yarn quality was decreased. Some of these problems were the tendency of the fibers to adhere to each other as they were discharged from the calender roll on the card, and the tendency of these sliver products to be more dense, i. e., less fluffy than untreated cotton or the cotton with the thermosetting resin. Table 3 shows the physical properties of the experiment and control 3/2 steep twill fabrics. The tearing

strength and flex abrasion of the cured fabrics made from blends of resin impregnated and untreated fibers were better in all cases than the control fabric conventionally treated and cured at about the same resin add-ons as in the blended fabrics. However, the reverse was true for the flat abrasion values. The conventionally padded control fabrics, where all the fibers were resin-treated, had higher crease angles than the fabrics composed of blends of resin impregnated and untreated fibers.

Table 3. --Physical properties of experimental and control 3/2 steep twill fabrics 126 x 50, 6.15 oz./sq. yd. used in manufacturing trouser cuffs

Item	Tearing strength Elmendorf		Abrasion resistance			Wrinkle recovery Monsanto crease angle, degree
	Warp	Filling	Flax		Flat	
			Warp	Filling		
50/50 percent warp and fill- ing resin add- on 5.5 percent equivalent	1967	1767	721	304	359	255
Control resin add-on 5.7 percent to fabric	933	1233	19	46	383	287
50/50 percent warp 25/75 percent filling resin add-on 4.3 percent equivalent	1700	2567	789	1122	394	249
Control resin add-on 4.5 percent to fabric	1200	1900	53	233	530	263
50/50 percent warp 75/25 percent filling resin add-on 6.6 percent equivalent	1767	1400	668	89	336	267
Control resin add-on 6.8 percent to fabric	933	1183	24	74	360	280

Trouser cuffs were subjected to cycles of washing and tumble drying to evaluate their resistance to abrasion. Cuffs were made in both warp and filling directions, (i. e., warp yarns running parallel with

the axis of the leg part of the cuff and filling yarns running parallel with the axis of the leg part of the cuff); however, only those cuffs cut in the warp direction are discussed in detail.

Figure 1 shows the effect of washing and tumble drying cycles on the wear of trouser

of the cuff, while the comparable control cuffs from fabrics treated conventionally

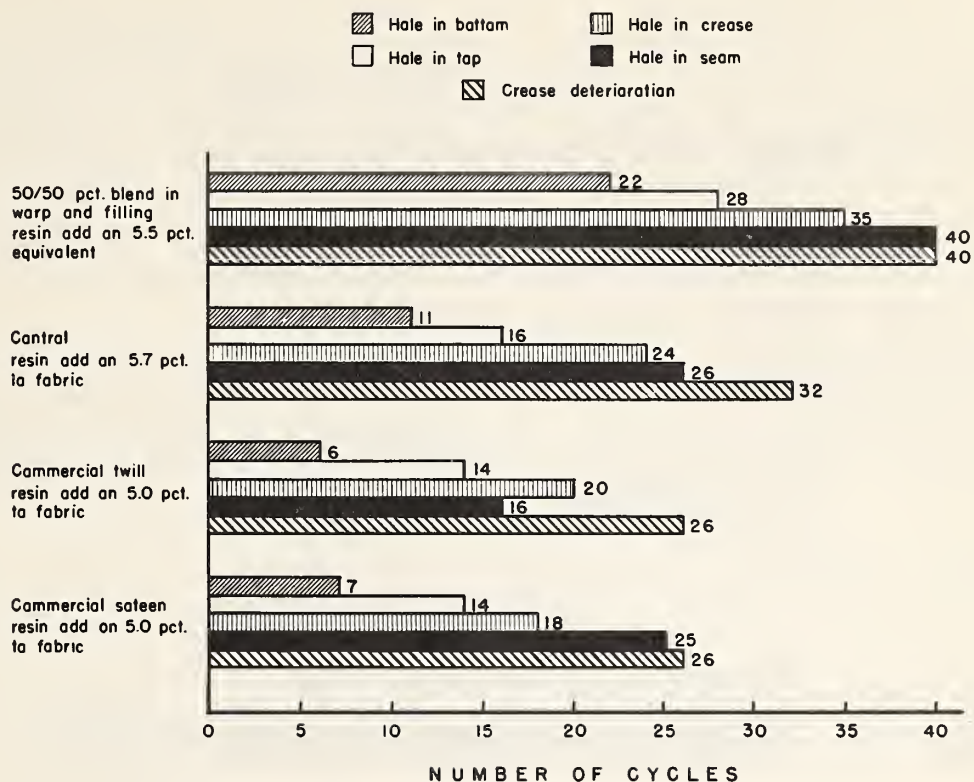


Figure 1. Effect of washing and drying cycles on specified types of initial defects occurring in trouser cuffs made from specified fabrics.

cuffs made from a fabric woven from yarns containing a blend of resin impregnated and untreated cotton fibers compared with a 7 oz. twill, 8 oz. sateen, and a control fabric conventionally padded. The bars show the wash-dry cycle at which defects first appeared in the trouser cuffs.

In all samples tested the defects appeared in the following order: (1) At the bottom of the cuff at the crease, (2) at the top of the cuff at the crease, (3) at the top of the cuff in the crease, (4) at the bottom of the cuff in the seam, and then (5) the number and magnitude of holes would increase in the crease until there was complete deterioration in the crease. The defect was considered a hole when there was evidence that one or more threads were broken.

The cuffs made from the fabric with the 50/50 percent blend of resin-impregnated and untreated fibers in both warp and filling were washed and dried 22 times before a broken thread was observed in the bottom

had a hole after the 11th cycle and the cuffs made from the treated twill fabrics and sateen fabrics had holes after 6 and 7 cycles, respectively.

Holes appeared at the top of the cuff after 14 cycles in the commercial twill fabrics and sateen fabrics and after 16 cycles in the conventionally padded 3/2 steep twill control; while the cuffs made from the fabric containing a 50/50 blend of resin impregnated and untreated fibers in the warp and filling went through 28 wash-tumble drying cycles before a hole appeared at the top of the cuff.

The commercial sateen, twill, and the control fabrics had holes in the crease after 18, 20, and 24 cycles, respectively, but no hole appeared in the crease of the cuffs made from the fabric with the blended fibers in it until after the 35th wash-tumble drying cycle.

After 16 cycles there was a hole at the bottom of the cuff in the seam in the commercial twill and after 25 and 26 cycles for the commercial sateen and the twill control, respectively. Crease deterioration was evident in the cuffs made from the two commercial fabrics after 26 and after 32 cycles for the control fabric but no more holes appeared in the cuffs made from the blended fibers through 40 wash-tumble drying cycles. Crease retention, flat drying properties, wash-and-wear appearance, etc., were very good in all cuffs. However, some minor pucker in the bottom of the cuff made from the fabrics containing blended fibers was evident.

Figure 2 shows the effect of washing and tumble drying on wear of trouser cuffs made

control fabrics conventionally padded to about the same resin contents.

The resistance to abrasion of the cuffs containing a blend of 25/75 percent resin impregnated and untreated fibers in the filling was somewhat better than the 50/50 percent blend in both warp and filling; but the wash-wear and smooth drying appearance of the cuff was not as good. The cuffs containing the 75/25 percent blend in the filling had very good crease retention and good wash-wear appearance but were inferior in abrasion resistance.

In all cases, however, the abrasion resistance of the cuffs made from fabric containing the blended fibers were superior to their control fabrics conventionally

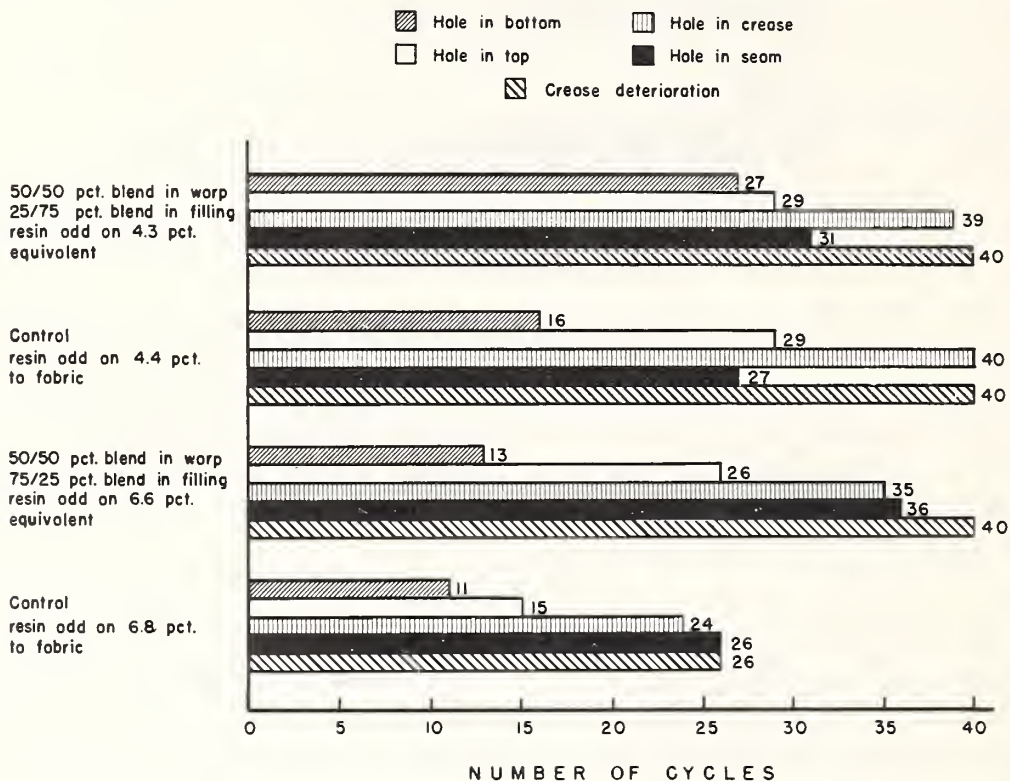


Figure 2. Effect of washing and tumble drying cycles on specified types of initial defects occurring in trouser cuffs made from a twill fabric composed of specified blends and resinated control.

from fabrics having a 50/50 percent blend of resin impregnated and untreated fibers in the the warp yarns and 25/75 and 75/25 percent blend of resin impregnated and untreated fibers in the filling yarns compared with

padded insofar as abrasion resistance was concerned.

Figure 3 shows the effect of curing time on the wear of trouser cuffs made from

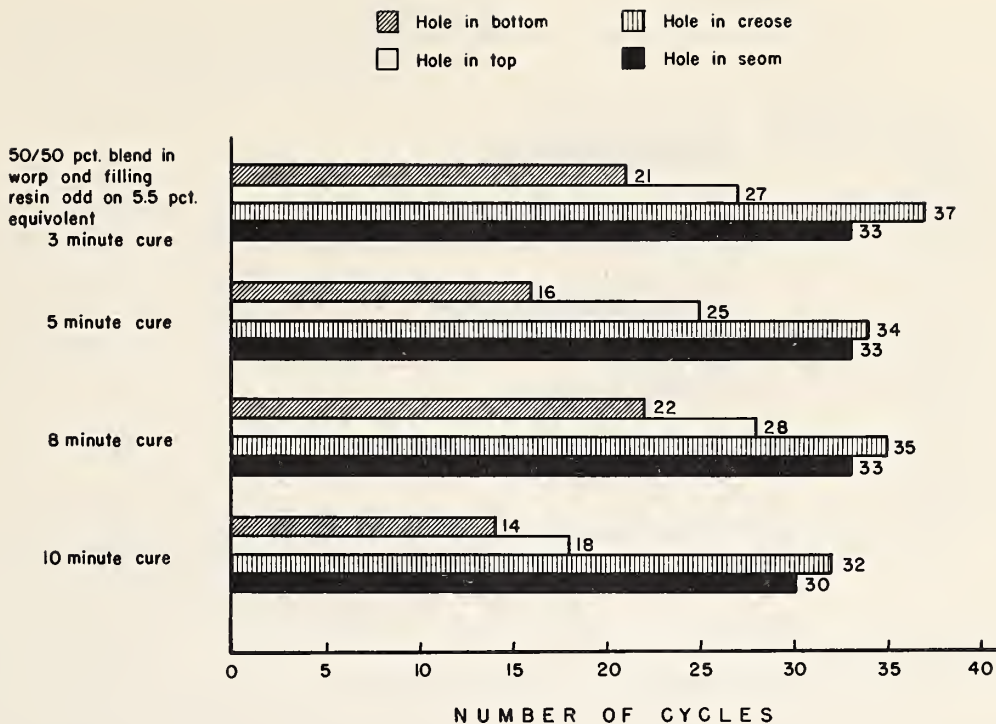


Figure 3. Effect of curing time on the wear of trouser cuffs as measured by specified types of initial defects occurring in washing and drying cycles.

fabrics having a 50/50 percent blend of resin impregnated fibers in the warp and filling yarns.

The time indicated on the chart is the time the cuffs were subjected to 320° F. discounting the heat-up, cool-down time.

The chart shows that at the shorter curing time abrasion of the cuffs was less which indicates that some of the resin was not cured and was removed during the washing cycles. At the higher or 10-minute curing time, abrasion occurred earlier which indicates a probable over-curing of the cuffs.

Some evidence existed that the type of dryer used, that is, electric or gas had an effect upon abrasion damage in treated cuffs. A duplicate 4-lb. wash load of trouser cuffs was made up and dried in the gas dryer to compare the abrasion wear with cuffs dried in an electric dryer. Results of this comparison are shown in figure 4. It is noted that in every comparison the cuffs dried in the gas dryer showed holes earlier than the cuffs dried in the electric dryer.

Temperatures as recorded from inside the dryer showed there was a gradual increase in temperature from ambient temperature up to a maximum of about 200° F. in the electric dryer during the 60-minute drying cycle.

Temperatures recorded for the gas dryer showed a wide variation from ambient temperature up to as high as 237° F. in some cases. The temperature would rise to a high of 237° F. and then drop to as low as 130° F., and then rise rapidly to the 230° F., or higher in cycles throughout the 60-minute drying period. Both dryers had a short period for cooling near the end of each drying cycle.

The following generalizations can be made of the performance of the filling face sateen fabrics that contained blends of treated and untreated fibers in their filling only:

(1) Crease retention in the leg portion of the simulated trousers was best in the samples having the cuffs cut in the warp direction. This was expected because the filling yarns contained the treated fibers

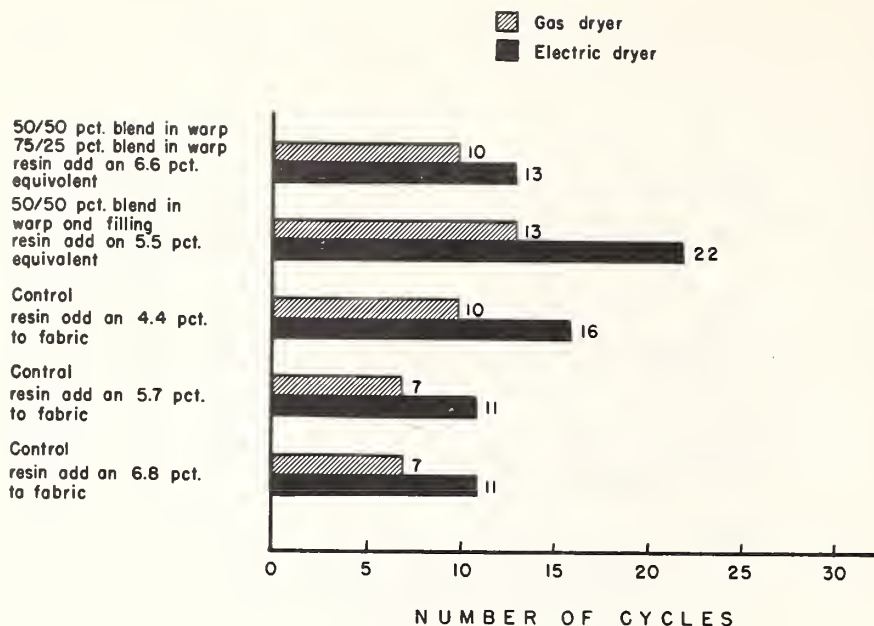


Figure 4. Effect of electric or gas dryer on the initial defects occurring in trouser cuffs made from specified fabrics and resin add-ons.

and were the yarns creased in leg portion when patterns were cut in the warp direction. Cuff creases were best when the pattern was cut in the filling direction. The samples containing the 33-1/3 percent blends retained better creases than the other samples.

(2) Flat drying properties improved with increased chemical add-on of the treated fiber portion of the blend.

(3) Some samples of the simulated trouser legs withstood as many as 60 washings and tumble dryings with little or no apparent damage from abrasion. Some abrasion damage was observable in all of the samples containing 18 percent imidazolidone resin add-on after 35 launderings, while the samples containing 75 percent of the 12 percent imidazolidone add-on fibers exhibited some abrasion damage after 35 launderings. Samples made from the 33-1/3 percent blends of methylol imidazolidone, a acrylic, and untreated fibers showed practically no abrasion damage through 55 launderings, when some samples containing the highest methylol imidazolidone add-on showed damage.

The following generalizations can be made of the performance of the 3/2 steep twill fabrics:

(1) Where the filling yarns contained blends of treated and untreated fibers, the crease retention characteristics were quite similar to those observed for the sateens above.

When the filling yarns were untreated and the warp yarns were made from the 50 percent blend of treated and untreated fibers, the crease retention properties of the fabrics and garments were not quite so good as the sateens above.

(2) Abrasion damage was more apparent in the cuffs of samples that had been cut in the warp direction than in those cut in the filling direction. Conversely, there was more crease abrasion in the leg portion of the samples cut in the filling direction than in those cut in the warp direction. There was no significant abrasion damage before the 30th wash-tumble dry cycle. This abrasion damage increased with increasing resin add-ons and with increasing proportions of treated fibers in the blends.

The following generalizations are applicable to the treated twill fabrics that contained treated fibers blended with untreated fibers in both the warp and filling directions:

(1) Of these samples, the crease retention of the leg portion was good in both

directions from which the pattern was cut, and the crease retention and shape holding characteristics of the cuffs were good regardless of the direction in which samples were cut.

Flat drying properties of these samples were good regardless of the direction in which the pattern had been cut; however, some seam pucker was noted in samples cut in the filling direction, while none was observed in the samples cut in the warp direction.

(2) More abrasion damage was noted in samples that had been cut in the warp direction than was apparent in samples that had been cut in the filling direction. Very few of the samples showed abrasion damage in less than 30 wash-tumble dry cycles.

The following generalization is applicable to both the sateen and the twill fabrics treated in the fabric form:

(1) Abrasion damage appeared after the third laundering tumble drying cycle and became excessive below 10 cycles.

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